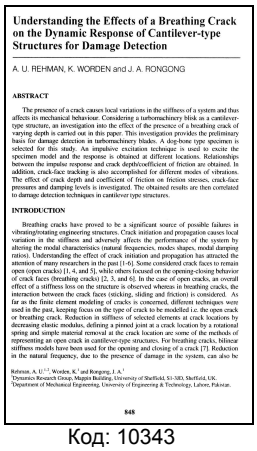

Understanding the Effects of a Breathing Crack on the Dynamic Response of Cantilever-type Structures for Damage Detection

A. U. REHMAN, K. WORDEN and J. A. RONGONG

ABSTRACT

The presence of a crack causes local variations in the stiffness of a system and thus affects its mechanical behaviour. Considering a turbomachinery blisk as a cantilever-type structure, an investigation into the effect of the presence of a breathing crack of varying depth is carried out in this paper. This investigation provides the preliminary basis for damage detection in turbomachinery blades. A dog-bone type specimen is selected for this study. An impulsive excitation technique is used to excite the specimen model and the response is obtained at different locations. Relationships between the impulse response and crack depth/coefficient of friction are obtained. In addition, crack-face tracking is also accomplished for different modes of vibrations. The effect of crack depth and coefficient of friction on friction stresses, crack-face pressures and damping levels is investigated. The obtained results are then correlated to damage detection techniques in cantilever type structures.

INTRODUCTION

Breathing cracks have proved to be a significant source of possible failures in vibrating/rotating engineering structures. Crack initiation and propagation causes local variation in the stiffness and adversely affects the performance of the system by altering the modal characteristics (natural frequencies, modes shapes, modal damping ratios). Understanding the effect of crack initiation and propagation has attracted the attention of many researchers in the past [1-6]. Some considered crack faces to remain open (open cracks) [1, 4, and 5], while others focused on the opening-closing behavior of crack faces (breathing cracks) [2, 3, and 6]. In the case of open cracks, an overall effect of a stiffness loss on the structure is observed whereas in breathing cracks, the interaction between the crack faces (sticking, sliding and friction) is considered. As far as the finite element modeling of cracks is concerned, different techniques were used in the past, keeping focus on the type of crack to be modelled i.e. the open crack or breathing crack. Reduction in stiffness of selected elements at crack locations by decreasing elastic modules, defining a pinned joint at a crack location by a rotational spring and simple material removal at the crack location are some of the methods of representing an open crack in cantilever-type structures. For breathing cracks, bilinear stiffness models have been used for the opening and closing of a crack [7]. Reduction in the natural frequency, due to the presence of damage in the system, can also be

Rehman, A. U.[1,2], Worden, K.[1] and Rongong, J. A.[1]
[1]Dynamics Research Group, Mappin Building, University of Sheffield, S1-3JD, Sheffield, UK.
[2]Department of Mechanical Engineering, University of Engineering & Technology, Lahore, Pakistan.

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A.U. Rehman, K. Worden, J.A. Rongong

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Ключевые слова:

Содержание.